PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H01P 1/213, 1/203 — A1

(11) International Publication Number: WO 00/33413

(43) International Publication Date: 8 June 2000 (08.06.00)

(21) International Application Number: PCT/SE99/02181

(22) International Filing Date: 24 November 1999 (24.11.99)

(30) Priority Data:
9804153-6 1 December 1998 (01.12.98) SE

(71) Applicant *(for all designated States except US)*: ALLGON AB [SE/SE]; P.O. Box 500, S-184 25 Åkersberga (SE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: LINDQVIST, Leif [SE/SE]; Slussbrovägen 4, S-184 41 Åkersberga (SE).

(74) Agent: EHRNER & DELMAR PATENTBYRÅ AB; P.O. Box 10316, S-100 55 Stockholm (SE).

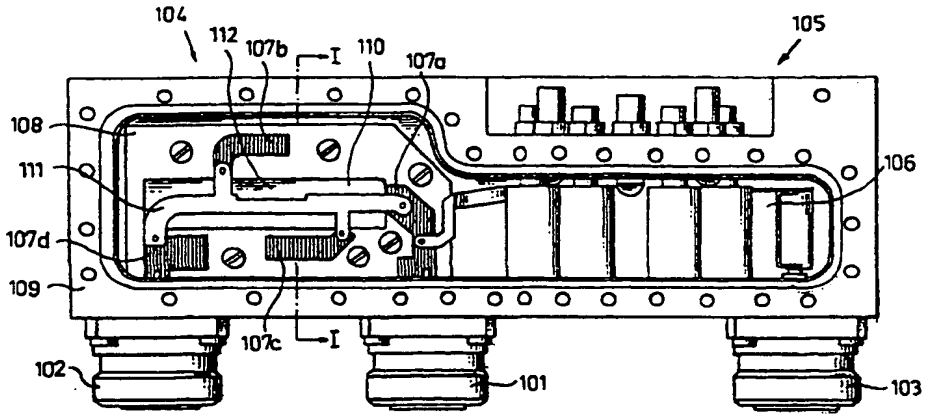
(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MICROSTRIP FILTER DEVICE



(57) Abstract

The present invention provides a filter for achieving a small, low cost filter means for high-power applications. This is achieved by providing a filter comprising a first and a second signal port (101, 102) arranged to pass signals of said first frequency band and at least a first ground plane means. Said filter further comprises an elongated conductor (111) coextending substantially in parallel with said ground plane means providing a first signal path for said frequency band between said first and second ports, at least a first conductive segment (107) having first radio frequency characteristics and being connected to said signal path at a first interconnection point and where said first characteristics and the position of said first interconnection point being selected such that radio frequencies outside said first frequency band are effectively attenuated in said first signal path. Said filter is characterized in that said elongated conductor and said conductive segment are formed partly by a planar dielectric material, having a relative dielectric constant substantially greater than one, provided with a conductive pattern, and partly by a self supporting conductor, said first interconnection point and said ground plane means being separated by a dielectric in the form of a gas.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

MICROSTRIP FILTER DEVICE

TECHNICAL FIELD OF INVENTION

The present invention relates in general to a high-power filter means and more particularly to a microstrip filter means.

DESCRIPTION OF RELATED ART

The continued growth of subscribers in different cellular systems has led to the situation where the call intensity, in peak traffic hours, reaches a maximum number of simultaneous calls due to limited frequency band availability. Thus, an operator might be restricted in adding new subscribers to the cellular system. This is solved by introducing new frequency bands used for communication. For instance, the mobile telephony system band 900 Mhz is supplemented in some areas by PCS/GSM 1800 Mhz. A subscriber having a dual band cellular phone may thus use any of the two frequency bands for communication resulting in less congestion, and the operator may add more subscribers to the combined system and will thus obtain even more revenues.

The use of two different frequency bands by one operator may require the operator to use two different antennas, one for each frequency band. However, it is beneficial for the operator to use the same cables to and from the two antennas, or the dual band antenna, serving a specific geographic area, and thus the need for a combiner or a filter for separating the different frequency bands arises.

Conventionally, such high-power filters may, for instance, be designed using cavity resonator filters according to known techniques. Such filters have generally been satisfactory in

function but are bulky, expensive and require manual tuning for optimal performance. Another example of a conventional high-power filter comprises a wire transmission line along a central axis of a cylindrical metal housing. The transmission line is connected to a series of circular metal plates that perpendicularly intersects the line. The plates are circumferentially spaced apart from the grounded housing by a dielectric material to create a capacitive coupling effective to shunt high frequencies. Such filters have also been generally satisfactory for suppressing harmonic spurs or high frequencies, but are massive in construction and expensive. It would be beneficial if a filter could be designed which is easy to manufacture, which does not require manual tuning, and which is smaller and less costly.

These requirements can be met by a microstrip, or a stripline, filter. However, microstrip filters are generally not suitable for high-power filter applications due to, for instance, high insertion loss, which reduces the power of the signal beyond acceptable values.

In US-5,153,541 'Multidielectric Microstrip Filter', assigned to Motorola Inc, a high-power microstrip filter is disclosed. Two different dielectric materials separate a transmission line and the ground plane, and radial pads, and the ground plane, respectively. The radial pads, cooperate, through a first of the two dielectric materials, with the ground plane for attenuating harmonic spurs. Along the transmission line several apertures are positioned and are filled with a second one of said two dielectric materials, preferably air, which reduces the capacitive coupling with the ground plane.

The use of several apertures interposed with support parts for supporting the transmission line results in a somewhat

cumbersome solution. The support parts are necessary, according to the cited patent, for supporting the transmission line and for enabling conductive coupling between the transmission line and the radial pads. One problem which may occur with this arrangement is that the support parts also introduce an increased capacitive coupling, caused by the circuit board at those points where high currents occur and where, possibly, the best need for a reduced capacitive coupling is present. It would be beneficial if this capacitive coupling, at the support parts, could be reduced.

It is also very difficult to selectively vary the characteristic impedance along the transmission line, which in turn may impede the freedom of design. It would be beneficial if the freedom in designing the filter characteristics could be increased.

The design in US 5,153,542 is also a broad-band design meaning that the filter is used for attenuating signals in a very broad frequency band above the low-pass frequency band. This filter design requirement may cause restrictions on the building practice.

SUMMARY OF INVENTION

The main object of the present invention is to achieve a high-power filter for filtering signals in a first frequency band. The filter should be small, capable of handling high-power applications, and easy to manufacture with low production costs.

Another object of the present invention, according to a preferred embodiment, is to provide a high-power filtering device which has an increased freedom in design of filter characteristics.

In more detail, the problems described above, how to achieve a small, low cost filter for high-power applications are solved by providing a filter comprising a first and a second signal port arranged to pass signals of said first frequency band and at least a first ground plane means. The filter further comprises an elongated conductor coextending substantially in parallel with said ground plane means providing a first signal path for said frequency band between said first and second ports, at least a first conductive segment having first radio frequency characteristics and being connected to said signal path at a first interconnection point, and said first characteristics and the position of said first interconnection point being selected such that radio frequencies outside said first frequency band are effectively attenuated in said first signal path. The filter is characterized in that said elongated conductor and said conductive segment are formed partly by a planar dielectric material, having a relative dielectric constant substantially greater than one, provided with a conductive pattern, partly by a self supporting conductor, said first interconnection point and said ground plane means being separated by a dielectric having approximately the same dielectric constant as vacuum.

According to one embodiment of the invention, the radio frequency characteristics is selected such that signals in a second frequency band above said first frequency band are effectively attenuated.

The objects of the present invention, according to one embodiment, are obtained by providing a filter where said signal path has narrower and broader parts to form different characteristic impedance along the signal path and where said characteristic impedance of said signal path cooperates with

the frequency characteristics of said conductive segment to attenuate frequencies in at least a second frequency band above said first frequency band.

An advantage with the present invention is that a small, low-cost filter device is achieved.

A further advantage is that a relative robust conductive material can be used where the current has its peak values and a material of high dielectric strength can be used where the electric field reaches high values. Thereby, a further advantage is achieved, namely that the losses can be kept low and power handling capabilities can be kept high.

If the dielectric material is a printed circuit board then high mechanical tolerances can be maintained so as to facilitate the production of a tuning free filter.

Another advantage is that a transmission line which is capable of handling high-power signals is achieved.

Another main advantage is that the relation between the distance to the ground plane and the width of the conducting portions can be chosen according to need or desire.

Further features of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow with reference to the accompanying drawings, wherein:

Figure 1 shows a combiner/splitter means according to a preferred embodiment of the invention;

Figure 2 shows a cross sectional view of the combiner/splitter means in figure 1 taken at line I-I;

Figure 3 shows a diagrammatic view of the embodiment depicted in figure 1;

Figure 4, 5a and 5b shows diagrammatic views of different applications of the combiner/splitter according to preferred embodiments of the invention;

Figure 6, 7 and 8 shows cross sectional views of combiners/splitters according to preferred embodiments of the invention;

Figure 9 shows a perspective view of the preferred embodiment of the invention disclosed in figure 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In figure 1 there is shown a filter device according to a preferred embodiment of the invention, with a lid removed for the sake of clarity. The filter device comprises a first input means 101, a first output means 102 and a second output means 103. The input signal comprises at least two different frequency bands, in this preferred embodiment the GSM band which is located at 900 Mhz and the PCN band which is located at 1800 Mhz. It is, however, possible to apply the invention

to other specific frequency bands as well. The input signal is fed to a first low-pass filter arrangement 104 which will be further described below and a second band-pass filter arrangement 105. The second filter arrangement, for filtering the input signal according to a second filtering scheme, receives the input signal through the input means 101 and passes it through a number of coaxial resonators 106 resulting in a signal which is band-pass filtered to let through the PCN band of 1800 Mhz. Such a filter arrangement is known per se and is not further described here.

It shall be noted that even though input and output means have conveniently been used for describing the function of the device in a simple and easy to understand manner, the device described in this paper is a duplex device. Thus, the terms input and output means do not indicate any direction of signal propagation, but rather, the signals may propagate from an input means, as well as into an output means.

The first filter arrangement, for filtering the input signal according to a first scheme, receives the input signal at the input means 101. The signal is further transferred on a conductive pattern 107 on a printed circuit board 108 towards an opening or an aperture 110 on said printed circuit board 108. The printed circuit board is secured on a metallic or more generally a conductive body 109 with bolts or, alternatively, by means of screws, an adhesive or any other fastening means. The conductive body 109 is effectively a ground plane located at a first distance from said conductive pattern 107. As an alternative, the ground plane may be affixed on the printed circuit board at an opposite side to the conductive pattern 107. The conductive pattern 107 consists, in this preferred embodiment, of four disjoint parts

107a-d. In other embodiments more or fewer parts may be employed.

In conductive contact with all the disjoint parts 107a-d of the conductive pattern 107 and positioned over the opening or aperture 110 is a stiff conductive transmission line 111 in the form of a conductive plate. Aligned with the opening or aperture 110 is also a recess in the conductive body 109 forming the ground plane, so that the transmission line 111 is located a second distance to said ground plane which is larger than said first distance. The transmission line 111 comprises protruding parts which are soldered to the end portions of the conductive pattern 107 so that a conductive coupling is achieved. Other methods of achieving this coupling may include conductive adhesive agents, bolts, screws or any other fastening means. The transmission line has broader and narrower passages 112, and the parts 107b and 107c, together with the protruding parts, form stubs, in order to achieve the desired filtering, according to known techniques. The part 107d of the conductive pattern 107 connects the transmission line 111 to the output means 102.

The stiff conductive transmission line can be achieved by for instance etching, which gives a very high precision, or punching or in any other way known to the man skilled in the art.

Figure 2 shows a cross section of figure 1 at line I-I. In this view, the distance D1 between the transmission line 111 and the conductive body 109, and the distance D2 between the conductive pattern 107 and the conductive body 109, which forms the ground plane, is clearly visible. An interconnection point 201 connects the transmission line 111 with the conductive pattern 107a. Such an interconnection point is

present for all disjoint parts of the conductive pattern 107 with the transmission line. These are all located so that air separates the interconnection point 201 and the ground plane 109. This is one significant step in achieving a high power filter since high currents may occur in these points. It shall be noted that an interconnection point is not necessarily the same as a soldering point. The interconnection point simply indicates the position where transmission line interfaces the stubs, which, in this particular preferred embodiment, is formed by the protruding part of the stiff conductive transmission line together with the disjoint parts, and has nothing to do with how the electrical or mechanical connection between the two is achieved.

Figure 3 shows a diagrammatic view of the preferred embodiment according to the invention. The low-pass filter 104 is connected to a first antenna 301 adapted for transmitting and receiving signals in a first frequency, in this embodiment around 800 Mhz for the GSM band. The band-pass filter 105 is similarly connected to a second antenna 302 adapted for transmitting and receiving signals in a second frequency band, in this embodiment around 1800 Mhz for the PCN band. Both filters 104 and 105 is connected to a common input means 101. A transmission line connects the first combiner/splitter 303 to a second similar combiner/splitter 304 for further transmission of the different frequency bands to respective application. Thus a single transmission line can be used for transmitting signals in the two frequency bands.

Figure 4 shows a different arrangement where a dual band antenna 402 is used. In this case, only one combiner/splitter 401 is used.

Figure 5a illustrates an arrangement where a dual band, dual polarization antenna 501 is used. First and second combiners/splitters 502, 503 are used, one for each polarization. Figure 5b shows an arrangement where two dual polarization antennas are used 504, 505, one for each frequency band. Thus, another two combiners/splitters 506, 507 are required.

Though one filter has been described as a low-pass filter and the other as a band-pass filter in this embodiment, it is obvious for the person skilled in the art that many types of filters can be designed using the inventive concepts in the present disclosure, for instance band-stop filters or two band-pass filters or any other combination suitable for achieving the filter schemes desired.

Figure 6 shows a cross sectional view of another preferred embodiment according the invention. In this embodiment a transmission line has a first and a second conductive strip 601 and 602 on opposite sides of a printed circuit board. The second conductive strip cooperates with a conductive body 604 having a recess, and forming a ground plane at a distance D1 from said second strip 602. The filter 600 also comprises a lid 605, in conductive contact with said conductive body and thus being a part of said ground plane and cooperating with the first conductive strip 601 at a distance D3. The lid 605 and the conductive body 604 form a housing for the filter. The filter further comprises conductive stubs 606 at a distance D3 from said ground plane.

By using the housing as a ground plane for the filter 600, inter-modulation problems can be avoided. It has been noted that using a conventional circuit board having a copper plated backside may cause inter-modulation problems when arranged in

a housing. The simple, yet ingenious, solution is to use a conductive, grounded housing as ground plane.

Figure 7 shows a cross sectional view of another preferred embodiment according to the invention. In this embodiment the distance D3 has been selected to be equal to the distance D1 in figure 6 by designing a lid 701 with a recess. In all other aspects the embodiment in figure 7 is the same as the embodiment in figure 6.

Figure 8 shows a preferred embodiment where a stripline has been used, the most significant difference being that a symmetric cross-section has been achieved. Thus, the conductive stubs 606 have the same material 603 with a relative high dielectric constant on both sides facing the ground plane means, whereas the transmission line 801 is separated from both of the ground plane means 802, 803 by air.

Figure 9 discloses the same preferred embodiment as previously disclosed in figure 1, also here with the lid removed for the sake of clarity.

CLAIMS

1. Filter for passing radio frequency signals of a first frequency band, comprising:
   - a first signal port arranged to pass signals of said first frequency band,
   - a second signal port arranged to pass signals of said first frequency band,
   - at least a first ground plane means,
   - an elongated conductor coextending substantially in parallel with said ground plane means and providing a first signal path for said frequency band between said first and second ports,
   - at least a first conductive segment having first radio frequency characteristics and being connected to said signal path at a first interconnection point, ⇒ galvanisk ?
   - said first characteristics and said first interconnection point being selected such that radio frequencies outside said first frequency band are effectively attenuated in said first signal path,

   characterized by
   - said filter being arranged in a housing (109; 604, 605),
   - said elongated conductor (111) and said conductive segment (107) being formed partly by a planar dielectric material (108), having a relative dielectric constant substantially greater than one, provided with a conductive pattern, partly by a self supporting conductor,

- said first interconnection point and said ground plane means being separated by a second dielectric having approximately the same dielectric constant as vacuum.

2. Filter according to claim 1, wherein
- said second dielectric is air.

3. Filter according to claim 1 or 2, wherein
- said housing is connected to signal ground,
- said planar dielectric material is secured to said housing so that said first conductive segment is positioned at a first distance from a wall of said housing and,
- said conductor and said interconnection points are positioned at a second distance from a wall of said housing.

4. Filter according to any of claims 1-3, wherein
- said at least first conductive segment is separated by a first distance (D1) from said ground plane means,
- said elongated conductor is separated by a second distance (D2) from said ground plane means,
- said first and second distance being different.

5. Filter according to any of claims 1-4, wherein
- said elongated conductor comprises distributed components in the form of narrower and broader parts (112),
- said distributed components cooperate with said first radio frequency characteristics and said interconnection points to effectively attenuate frequencies outside said first frequency band.

6. Filter according to any of claims 1-4, wherein

- said elongated conductor is arranged to form a transmission line between said first signal port and said second signal port.

7. Filter according to any of claims 1-6, wherein
- said at least first conductive segment extends at least partly in parallel with said elongated conductor.

8. Filter according to any of claims 1-7, wherein
- said filter is arranged in a housing,
- at least one further filter is arranged in said housing having said first signal port in common with said filter and a further third signal port,
- said at least one further filter is arranged for attenuating signals outside a second frequency band.

9. Filter according to any of claims 1-8, wherein
- a second elongated conductor coextends substantially in parallel, and cooperating, with said ground plane means and with said first elongated conductor to form said transmission line,
- said first elongated conductor is applied to a first side of said planar dielectric material,
- said second elongated conductor is applied to a second side, opposite said first side, of said planar dielectric material.

10. Filter according to any of claims 1-9, wherein
- said at least first ground plane means faces said first elongated conductor at a first distance,
- a second ground plane means faces said second elongated conductor at a second distance.

11. Filter according to claim 10, wherein
- said first and second distance are different.

12. Filter according to any of the claims above, wherein

- said filter is designed to attenuate signals in a second frequency band above said first frequency band.

Fig. 1

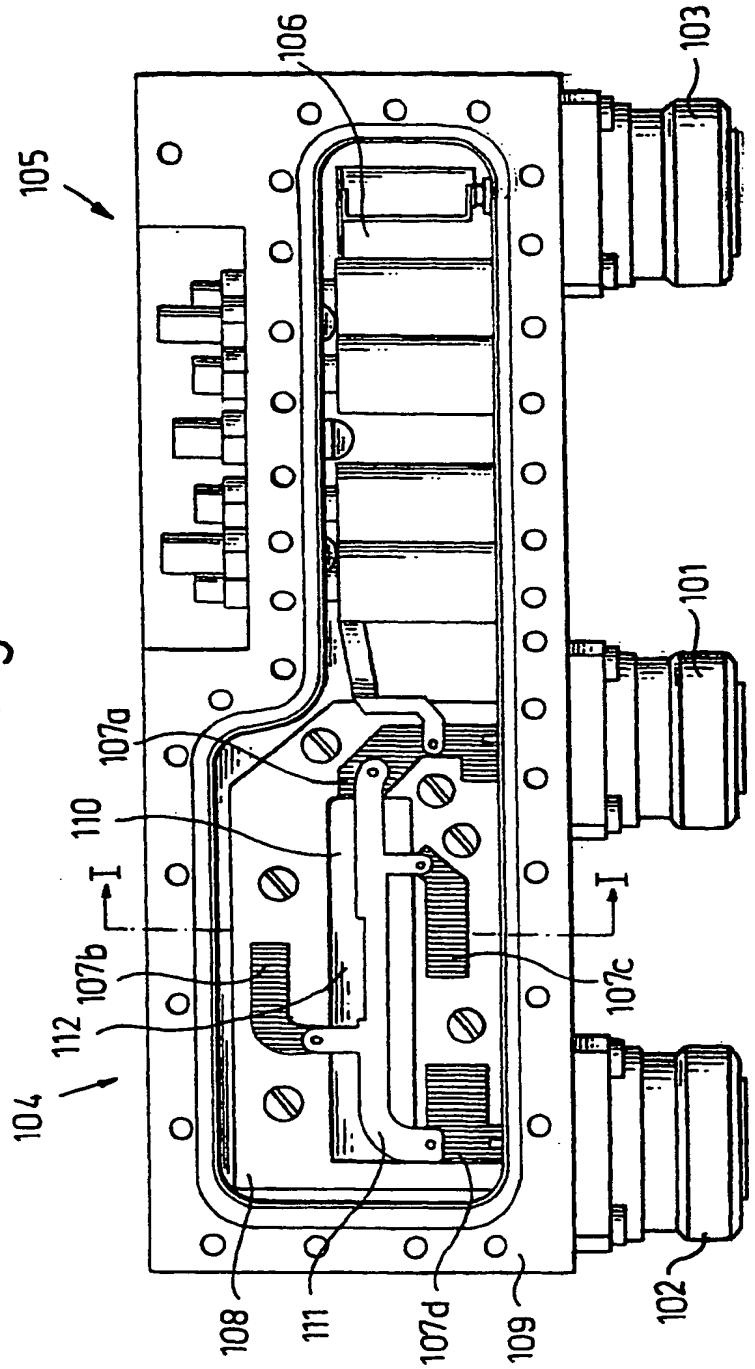

106
103
105
101
107a
110
I
I
107b
107c
112
104
108
111
107d
109
102

Fig. 2

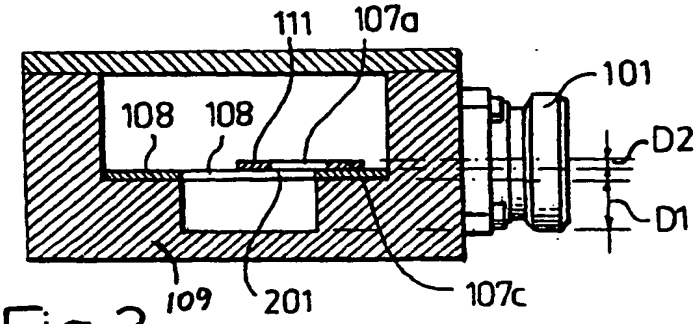


Fig. 3

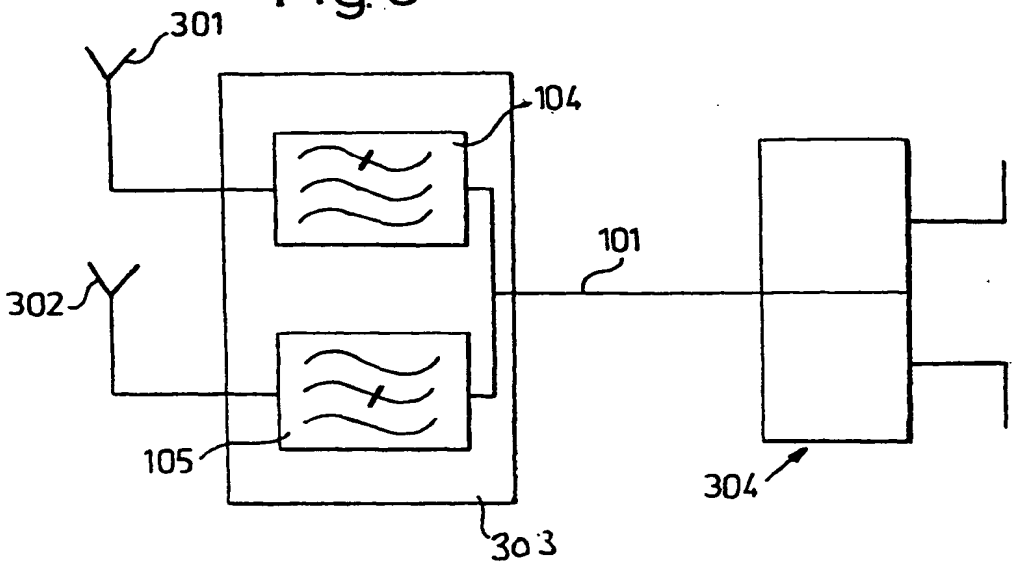


Fig. 4

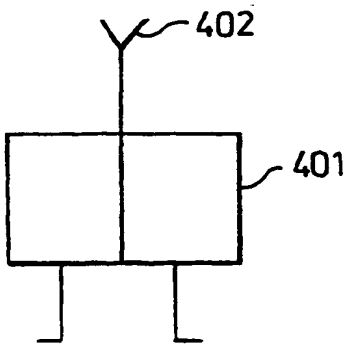


Fig. 5a

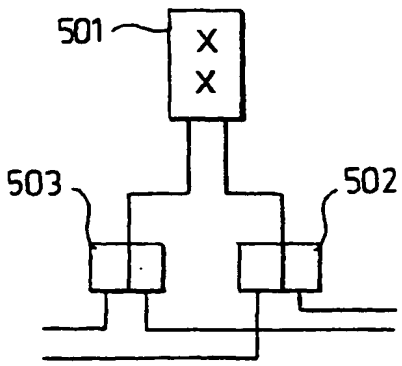


Fig. 5b

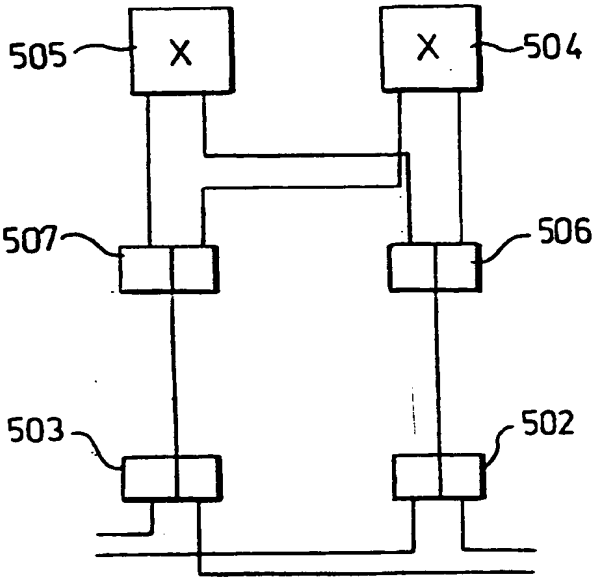


Fig.6

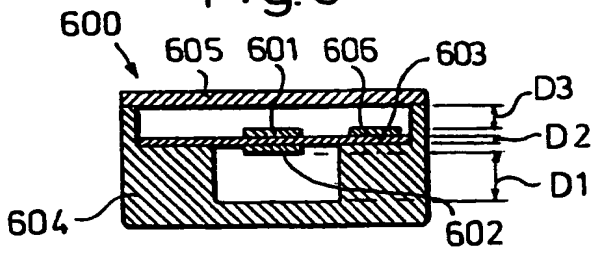


Fig. 7

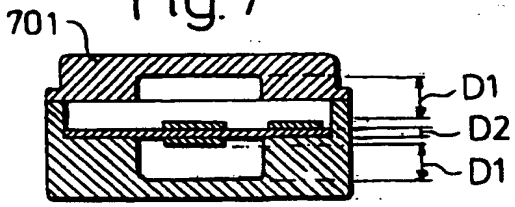
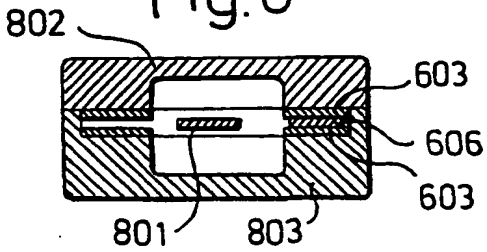


Fig. 8



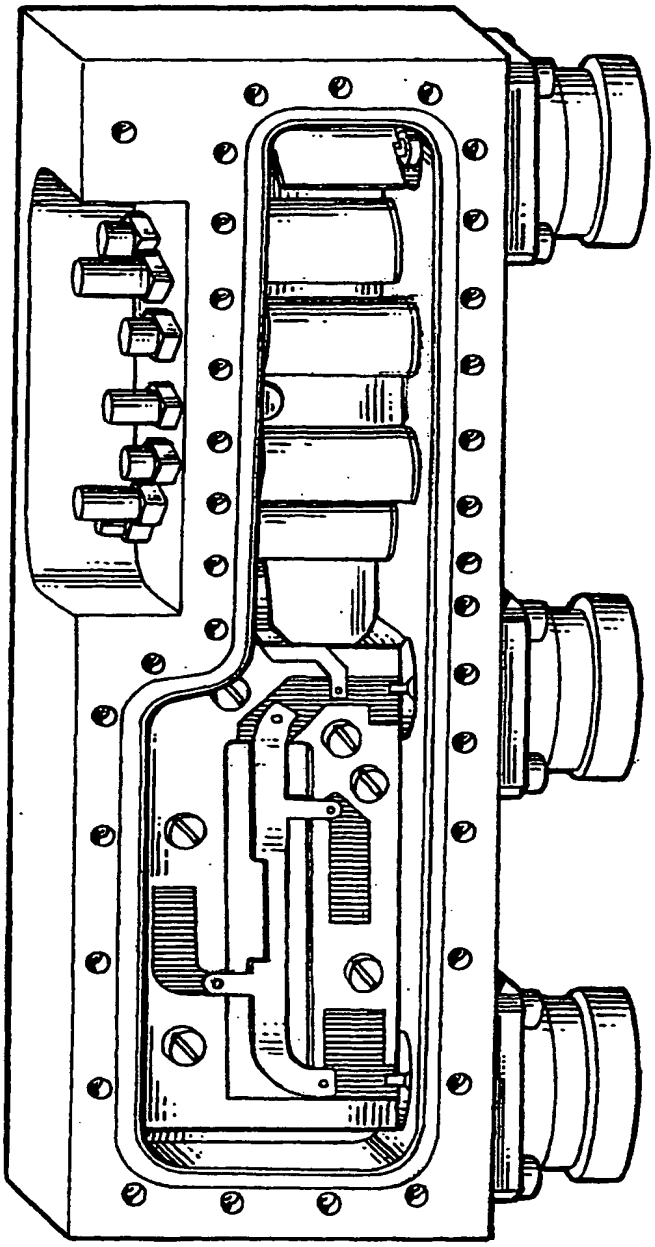


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/02181

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01P 1/213, H01P 1/203
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5192927 A (JAU-HUEI LIN), 9 March 1993 (09.03.93), see the whole document ---	1-12
A	US 5317291 A (ALLEN F. PODELL), 31 May 1994 (31.05.94), see the whole document --- --------	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw douhts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2000	02-05-2000
Name and mailing address of the ISA/ Swedish Patent Offic Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bo Gustavsson/ae Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/SE 99/02181

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5192927 A	09/03/93	NONE	
US 5317291 A	31/05/94	MX 9401268 A	31/08/94